



YAKEEN

Lecture - 3

SOLUTIONS



By

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# TODAY'S GOAL

RAOULT'S LAW

IDEAL SOLUTION





# RAOULT'S LAW

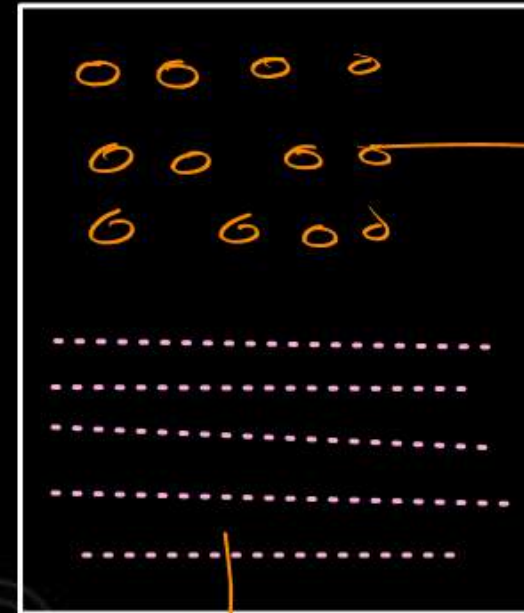


V.P. of any Component in solution is equal to product of V.P. of that Component in pure form & mole fraction of that Component in solution.



$P_A^0 = \text{V.P. of A}$   
In Pure form

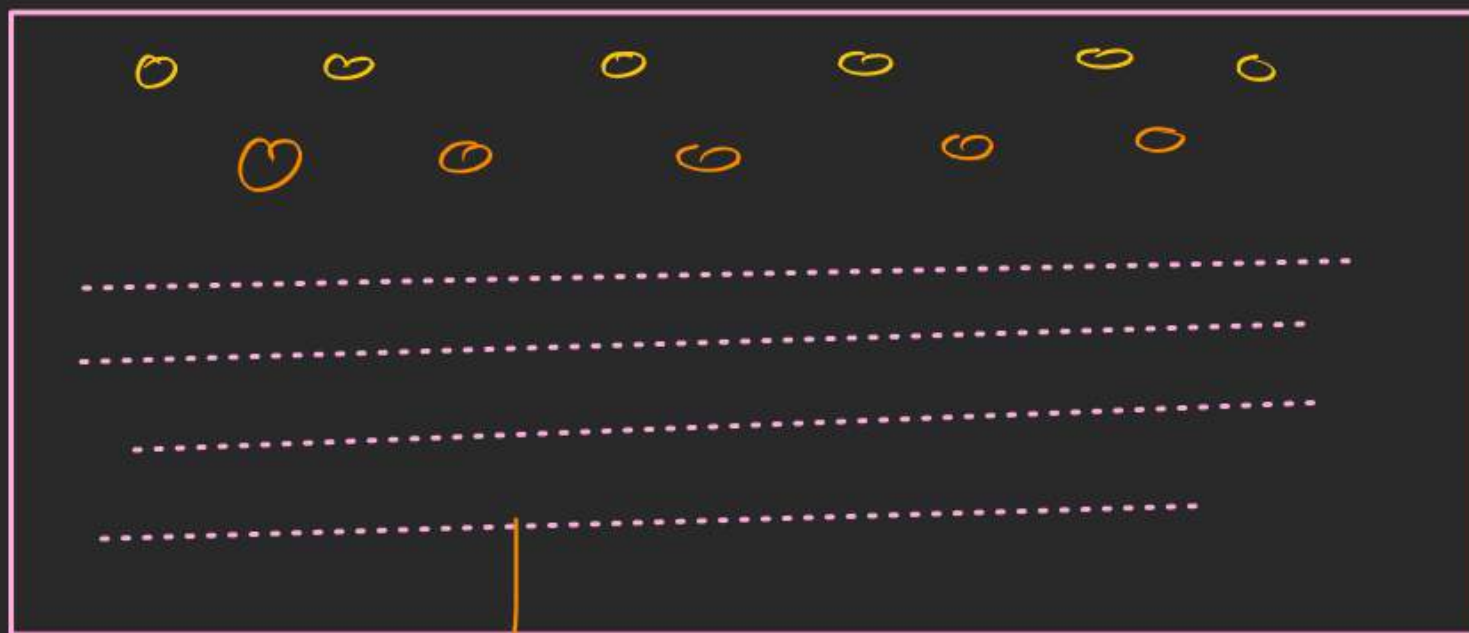
↓  
Volatile Solvent  
(A)



$P_B^0 = \text{V.P. of B}$   
in pure form

↓  
Volatile Solute  
B





Solution

$$P_A = v.p. \text{ of } A \text{ in solution}$$

$$P_B = v.p. \text{ of } B \text{ in solution}$$

$$P_A = P_A^0 X_A$$

$$P_B = P_B^0 X_B$$



# RAOULT'S LAW FOR VOLATILE SOLUTE



volatile solvent (A)

$$P_A^0 \neq 0$$

+



solute (B)

volatile

$$P_B^0 \neq 0$$

=



solution

$$P_A = P_A^0 \chi_A$$

$$P_B = P_B^0 \chi_B$$

$$P_S = P_A^0 \chi_A + P_B^0 \chi_B$$

v.p. of solution







$$P_B^0 > P_A^0$$

V.P.

$P_A^0$

$$x_B = 0$$
$$x_A = 1$$

$$P_B = P_B^0 x_B$$

$$P_S = P_A^0 x_A + P_B^0 x_B$$

$$P_A = P_A^0 x_A$$

$x_B$

$$x_B = 1$$
$$x_A = 0$$

$P_B^0$

$$P_S = P_A^0 \chi_A + \underbrace{P_B^0 \chi_B}_{\text{circled}}$$

$$\chi_B = 0, \chi_A = 1$$

$$\textcircled{P_S} = P_A^0$$

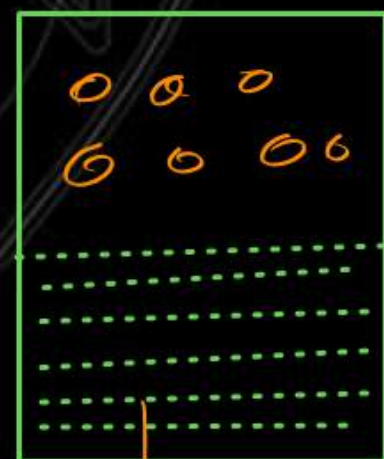
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$$\chi_B = 1, \chi_A = 0$$

$$\boxed{P_S = P_B^0}$$

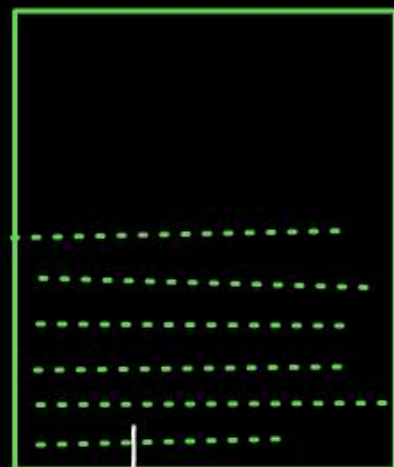


# RAOULT'S LAW FOR NON-VOLATILE SOLUTE



↓  
Volatile  
Solvent  
↓  
 $P_A^0 \neq 0$

+



↓  
Non-Volatile  
Solute  
↓  
 $P_B^0 = 0$

=



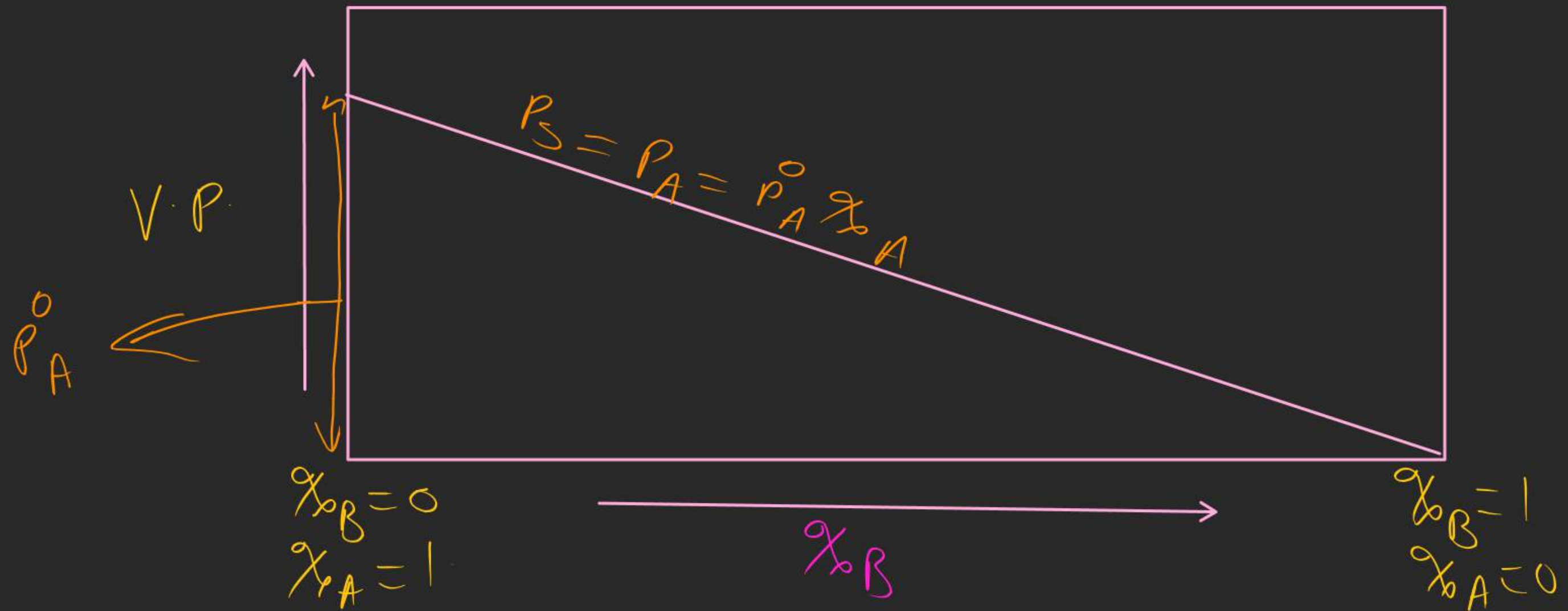
↓  
Solution.

$$P_s = P_A^0 \chi_A + P_B^0 \chi_B$$



$$P_S = P_A^0 \chi_A = P_A \quad (\text{as } P_B^0 = 0)$$

↓  
Raoult's law for non-volatile solute

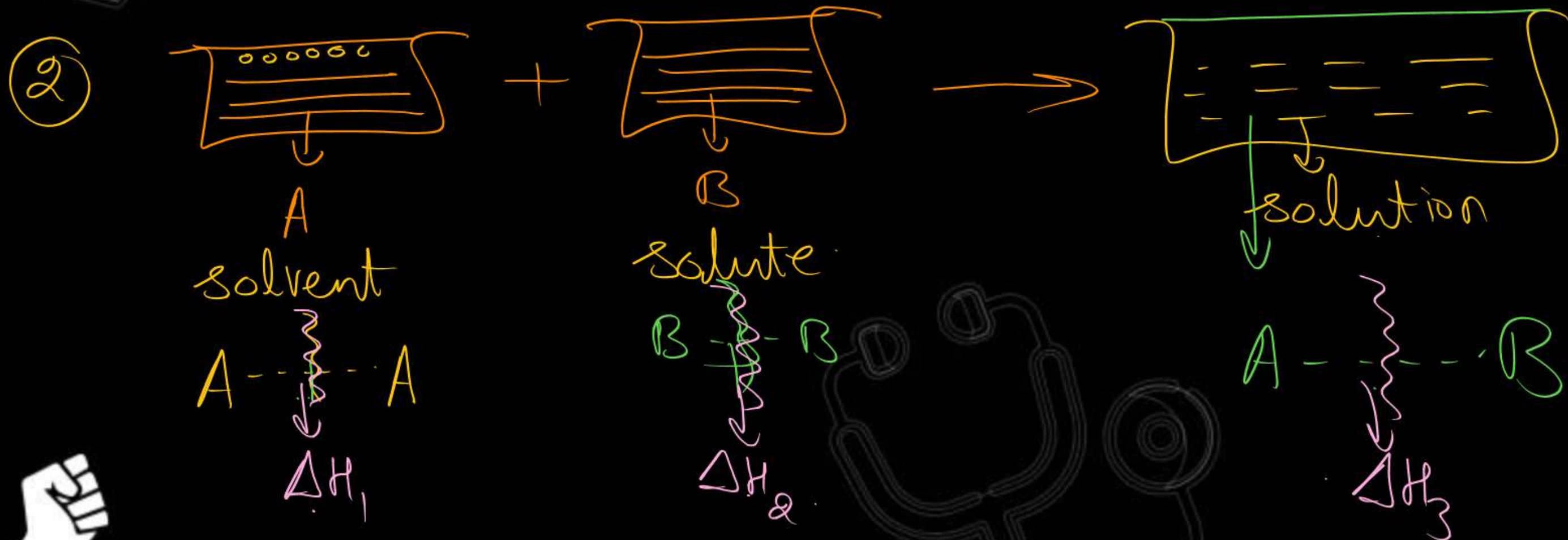




# IDEAL SOLUTION



① Solution which obey Raoult's law at all temperature & Pressure







# PROPERTIES OF IDEAL SOLUTION



(a)

$$P_S = \underline{P_A^0} \underline{x_A} + \underline{P_B^0} \underline{x_B}$$

$$P_S = P_A^0 (1 - x_B) + P_B^0 x_B$$

$$P_S = \underbrace{(P_A^0)}_{\text{circled}} - \underline{P_A^0} \underline{x_B} + \underline{P_B^0} \underline{x_B}$$

$$P_S = (\underline{P_B^0} - \underline{P_A^0}) \underline{x_B} + \underline{P_A^0}$$

$$(x_A + x_B = 1)$$

$$x_A = (1 - x_B)$$

$$x_B = 1 - x_A$$



(b)  $\Delta H_{\text{mixing}} = 0$

(c)  $\Delta V_{\text{mixing}} = 0$

★ (d)  $\Delta S_{\text{mixing}} = (+)ve$

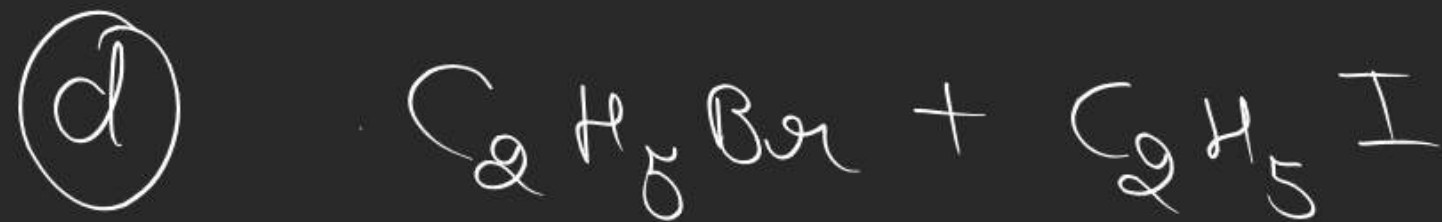
★ (e)  $\Delta G_{\text{mixing}} = (-)ve$

→ for every spontaneous  
reaction



for ex - same Homologous series

(a) n-Heptane + n-Octane



# MOLE FRACTION OF ANY COMPONENT IN VAPOUR PHASE

$Y_A$  = Mole fraction of A in Vapour phase.

using D.P.P. (Dalton's law of Partial Pressure)

$$P_A = Y_A P_T$$

$$(P_T = P_S)$$



$$P_A = Y_A P_S$$

$$Y_A = \frac{P_A}{P_S}$$

$$Y_A = \frac{P_A^0 X_A}{P_A^0 X_A + P_B^0 X_B}$$

$$P_B = Y_B P_S$$

$$Y_B = \frac{P_B}{P_S}$$

$$Y_B = \frac{P_B^0 X_B}{P_A^0 X_A + P_B^0 X_B}$$



$$\text{if } x_A = x_B \text{ \& } P_A^o > P_B^o$$

$$\Rightarrow Y_A > Y_B$$

$$\text{\& also } Y_A > x_A$$

$$\frac{P_S}{P_S} = 1$$

$$x_A + x_B = 1$$

$$Y_A + Y_B = 1$$

$$\frac{P_A}{P_S} + \frac{P_B}{P_S} = 1$$

$$\frac{P_A + P_B}{P_S} = 1$$

Benzene and toluene form an ideal solution and V.P. of pure benzene and toluene are 160 mm of Hg and 60 mm of Hg. Calculate partial pressure of benzene and toluene and total pressure also

- (a) Containing equal mass of both benzene and toluene → Molar mass of Benzene = 78 g  
Toluene = 92 g
- (b) Containing equal molecules of both benzene and toluene
- (c) Containing 1 mole of benzene and 4 moles of toluene
- (d) Also calculate mole fraction of Benzene and toluene in vapour phase if equal moles of benzene and toluene mixed

Ans A → Toluene  
B → Benzene

$$P_S = P_A^0 x_A + P_B^0 x_B$$

$$P_B^0 = 160 \text{ mm of Hg}, \quad P_A^0 = 60 \text{ mm of Hg}$$

$$P_A = ?$$

$$P_B = ?$$

$$P_S = ?$$



Let mass of Benzene & Toluene =  $78 \times 92 = 7176$

$$n_B = \frac{7176}{78} = 92$$

$$n_T = \frac{7176}{92} = 78$$

$$x_A = \frac{78}{78+92} = \frac{78}{170} = 0.46$$

$$x_B = 1 - x_A = 0.54$$

$$P_A = P_A^0 x_A$$

$$P_A = 60 \times 0.46$$

$$P_B = P_B^0 x_B$$

$$P_B = 160 \times 0.54$$



$$P_S = P_A + P_B$$

$$P_S = 60 \times 0.46 + 160 \times 0.54 =$$

$$= 27.6 + 86.4 = 114$$

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(b) Let molecules of Benzene & Toluene =  $N_A$

$$\underline{n_A} = \frac{N_A}{N_A} = 1 \quad \bigg| \quad n_B = \frac{N_A}{N_A} = 1$$

$$\%_A = \frac{\underline{n_A}}{\underline{n_A} + \underline{n_B}} = \frac{1}{2} = 0.5 \quad \bigg| \quad \%_B = 0.5$$

$$P_A = P_A^0 \chi_A = 60 \times \frac{1}{2} = 30 \text{ mm of Hg}$$

$$P_B = P_B^0 \chi_B = 160 \times \frac{1}{2} = 80 \text{ mm of Hg}$$

$$P_S = \underline{P_A \chi_A} + P_B^0 \chi_B$$

$$= 30 + 80 = 110 \text{ mm of Hg}$$

©

$$n_B = 1$$

$$n_A = 4$$

$$\chi_A = \frac{4}{5} = 0.8$$

$$\chi_B = 1 - \chi_A = 0.2$$

$$P_A = 60 \times 0.8 = 48 \text{ mm of Hg}$$

$$P_B = 160 \times 0.2 = 32 \text{ mm of Hg}$$

$$P_S = 48 + 32 = 80 \text{ mm of Hg}$$



$$(d) \quad Y_A = \frac{P_A^0 x_A}{P_S} = \frac{3\phi}{11\phi} = \frac{3}{11}$$

$$n_A = n_B$$

$$x_A = x_B = \frac{1}{2}$$

$$Y_B = \frac{P_B^0 x_B}{P_S} = \frac{8\phi}{11\phi} = \frac{8}{11}$$



The vapour pressure of two liquids  $P$  and  $Q$  are 80 and 60 torr respectively. The total vapour pressure of solution obtained by mixing 3 moles of  $P$  and 2 moles of  $Q$  would be **[AIIMS 2012]**

- (a) 140 torr  
(c) 68 torr

- (b) 20 torr  
(d) 72 torr

Ans

$$\begin{array}{l|l}
 P_A^0 = 80 & n_A = 3 \\
 P_B^0 = 60 & n_B = 2 \\
 P_S = & x_A = \frac{3}{5} = 0.6 \\
 & x_B = \frac{2}{5} = 0.4
 \end{array}$$

$$\begin{aligned}
 P_S &= P_A^0 x_A + P_B^0 x_B \\
 &= 80 \times \frac{3}{5} + 60 \times \frac{2}{5} \\
 &= 48 + 24 = 72 \text{ torr}
 \end{aligned}$$



$p_A^\circ$  and  $p_B^\circ$  are the vapour pressure of pure liquid components A and B respectively of an ideal binary solution. If  $\chi_A$  represents the mole fraction of component A, the total pressure of the solution will be **[CBSE AIPMT]**

(a)  $p_A^\circ + \chi_A (p_B^\circ - p_A^\circ)$

(b)  $p_A^\circ + \chi_A (p_A^\circ - p_B^\circ)$

(c)  $p_B^\circ + \chi_A (p_B^\circ - p_A^\circ)$

☒ (d)  $p_B^\circ + \chi_A (p_A^\circ - p_B^\circ)$

Ans

$$P_S = p_A^\circ \chi_A + p_B^\circ (1 - \chi_A)$$

$$P_S = p_A^\circ \chi_A + p_B^\circ - p_B^\circ \chi_A$$

$$P_S = (p_A^\circ - p_B^\circ) \chi_A + p_B^\circ$$





For an ideal solution, the correct option is

[NEET-2019]

(a)  $\Delta_{\text{mix}} S = 0$  at constant T and P ✗

(b)  $\Delta_{\text{mix}} V \neq 0$  at constant T and P ✗

(c)  $\Delta_{\text{mix}} H = 0$  at constant T and P

(d)  $\Delta_{\text{mix}} G = 0$  at constant T and ✗





Which one of the following is incorrect for ideal solution?

[NEET-Phase-2-2016]

(a)  $\Delta H_{\text{mix}} = 0$  ✓

(c)  $\Delta P = P_{\text{observed}} - P_{\text{calculated by Raoult's law}} = 0$  ✗

(b)  $\Delta U_{\text{mix}} = 0$  ✓

(d)  $\Delta G_{\text{mix}} = 0$  ✓

↓  
Wrong

$$\Delta P = P_{\text{observed}} - P_{\text{calculated by Raoult's law}} = 0$$



Which one is not equal to zero for an ideal solution?

(a)  $\Delta P = P_{\text{observed}} - P_{\text{Raoult}}$

(c)  $\Delta S_{\text{mix}}$

(b)  $\Delta H_{\text{mix}}$

(d)  $\Delta V_{\text{mix}}$

[AIPMT-2015]





Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is constant at 25°C (Given, Vapour Pressure Data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa) [NEET-2016]

- (a) Not enough information is given to make a prediction ✗
- (b) The vapour will contain a higher percentage of benzene
- (c) The vapour will contain a higher percentage of toluene
- (d) The vapour will contain equal amounts of benzene and toluene

Ans

$$n_A = n_B \Rightarrow x_A = x_B = \frac{1}{2}$$

$\downarrow$   
Toluene
 $\downarrow$   
Benzene

$y_A = ?$   
 $y_B = ?$

$p_B^0 = 12.8 \text{ kPa}$   
 $p_A^0 = 3.85 \text{ kPa}$







$$\text{as } P_B^0 > P_A^0 \quad (x_A = x_B)$$

$$\therefore \frac{Y_B}{\downarrow} \text{Benzene} > \frac{Y_A}{\downarrow} \text{Toluene}$$



At a given temperature, the vapour pressure in mm of Hg of a solution of two volatile liquids A and B is given by equation  $P = 120 - 80 \chi_B$

Calculate V.P. of pure A and B at same temperature

Ans

$$P_S = 120 - 80 \chi_B$$

$$P_S = \underline{-80 \chi_B} + \underline{120}$$

$$P_A^0 = ?$$

$$P_B^0 = ?$$

$$P_S = \frac{(P_B^0 - P_A^0) \chi_B}{1} + P_A^0$$

$$P_A^0 = 120$$

$$P_B^0 - P_A^0 = -80 \Rightarrow P_B^0 - 120 = -80 \Rightarrow P_B^0 = 40$$





Two liquids A and B form an Ideal solution at 300 K the V.P. of solution having 1 mole of A and 3 mole of B is 550 mm of Hg. At same temperature if 1 more mole of B is added to solution, V.P. of solution increases by 10 mm of Hg. Determine V.P. of A and B in pure state.

Ans

$$P_S = 550 \text{ mm of Hg}$$

$$n_A = 1$$

$$n_B = 3$$

$$\chi_A = \frac{1}{4} = 0.25$$

$$P_A^0 = x \text{ mm of Hg}$$

$$P_B^0 = y \text{ mm of Hg}$$

$$\chi_B = \frac{3}{4} = 0.75$$

$$n_B' = 4$$

$$n_A' = 1$$

$$P_S' = 560 \text{ mm of Hg}$$

$$\chi_A' = \frac{1}{5} = 0.2$$

$$\chi_B' = \frac{4}{5} = 0.8$$





$$\underline{P_A^0} \underline{x_A} + \underline{P_B^0} \underline{x_B} = P_S$$

$$\underline{0.2} \times \left[ \cancel{0.25} x + \underline{0.75} y = 550 \right]$$

$$\underline{0.25} \times \left[ \cancel{0.2} x + \underline{0.8} y = 560 \right]$$

$$0.15 y = 110$$

$$\pm 0.2 y = \pm 140$$

$$\pm 0.05 y = \pm 30$$

$$y = \frac{30}{0.05}$$

$$y = \frac{30 \times 100^{20}}{5} = 600$$

$$x = 400$$



The V.P. of pure liquids A and B are 450 and 700 mm of Hg. Find out composition of liquid mixture if total vapour pressure is 600 mm of Hg. Find composition of vapour phase

As  $P_A^0 = 450$

$P_B^0 = 700$

$x_A = ?$

$x_B = ?$

$P_S = 600$

$P_S = (P_B^0 - P_A^0) x_B + P_A^0$

$600 = 250 x_B + 450$

$150 = 250 x_B$

$x_B = \frac{150}{250} = \frac{3}{5}$



$$x_A = 1 - x_B = 1 - \frac{3}{5} = \frac{2}{5}$$

$$Y_A = \frac{P_A^0 x_A}{P_S} = \frac{450 \times 0.2}{600} = \frac{90}{600} = \frac{9}{60}$$

$$Y_B = 1 - Y_A = 1 - \frac{9}{60} = \frac{51}{60}$$







*thanks  
for watching*



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